COSMOS

ADDING VALUE TO CAMELINA AND CRAMBE OIL

**C**amelina & crambe **O**il crops as **S**ources for **M**edium-chain **O**ils for **S**pecialty oleochemicals

(Grant Agreement No. 635405)

# D 5.1 Report on composition of crambe and camelina oilseed side streams (seed meals & crop residues)


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## Contents

# 1 Introduction of the European Horizon 2020 EU-project COSMOS

**This 4.5-year project aims at reducing the dependence of Europe's oleochemical industry on imported plant oils by turning camelina and crambe into profitable, sustainable, multipurpose, non-transgenic European oil crops.**

The European oleochemical industry currently relies on imported coconut and palm kernel oils and fatty acids and on castor oil as sources for medium-chain fatty acids (MCFA, C10–C14) and medium-chain polymer building blocks. These are needed for the production of plastics, surfactants, detergents, lubricants, plasticisers and other products.

COSMOS aims at reducing this dependence by turning the currently underutilised domestic oil crops Camelina and Crambe into profitable, sustainable, multipurpose, non-transgenic European oil crops for the production of oleochemicals. Seed properties will be screened and optimised through genetic techniques aiming at high yield, low resource inputs, optimisation of the value generated from vegetative tissues and fatty acid profiles adapted to industrial needs. Large-scale field trials will be performed at different locations in Europe to assess the potential of the crops in terms of cultivation practices, seed yield, oil content, ease of harvesting, and resource inputs.

Extracted oils will be fractionated into various fatty acid types (monounsaturated versus polyunsaturated) by selective enzyme technologies and extraction processes. The monounsaturated long-chain fatty acids so obtained will be converted to medium-chain fatty acids (MCFA) and high-value building blocks for bio-plastics and flavour and fragrance ingredients through chemical and enzymatic chain cleavage processes. The ω3-rich polyunsaturated fatty acids (PUFA) fraction will be purified for use in food and feed ingredients. Vegetative tissues such as straw, leaves and press cake will be fed to insects producing high-value proteins, chitin and fats. Insect fats and proteins will be isolated and prepared for use in food and feed products. The overall economic, social and environmental sustainability as well as life cycle of the whole value chain will be assessed. The impact of the project for Europe will be assessed in terms of value chain potentials for value creation and number of jobs that can be created.

**Project partners**

The project comprises eighteen partners, of which 50% are SMEs and large enterprises and the remaining 50% are universities and research institutes. The research consortium is being managed by Wageningen Food & Biobased Research.

Institutes and universities include Alma Mater Studiorum – Università di Bologna (Italy), Ernst-Moritz-Arndt-Universität Greifswald (Germany), Uniwersytet Warminsko–Mazurski w Olsztynie (Poland), Wageningen University and Research (The Netherlands), Université de Rennes 1 (France), Centre for Physical Sciences and Technology (Lithuania), Centre for Renewable Energy Sources and Saving (Greece) and Imperial College of Science, Technology and Medicine (UK).

Companies include Enzymicals AG, Institut für Energie- und Umweltforschung Heidelberg GmbH and Nova-Institut für Politische und Ökologische Innovation GmbH from Germany, InCatT B.V. (a spin-off company of the University of Amsterdam), Proti-Farm R&D B.V. and Linnaeus Plant Sciences B.V. from the Netherlands, Solutex GC, S.L. from Spain, Apeiron Synthesis from Poland and Arkema from France.

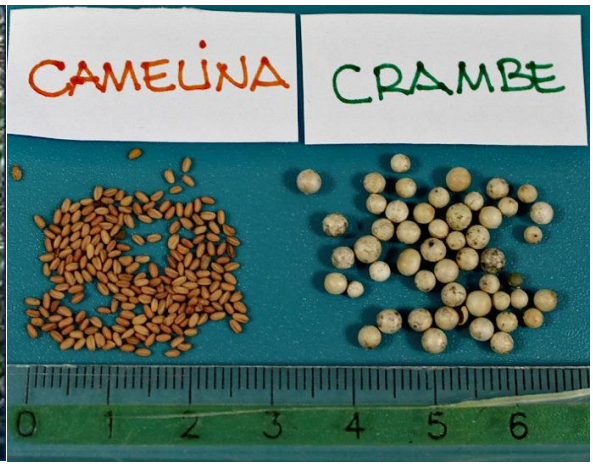
A project website is available at: www.cosmos-h2020.eu.

COSMOS receives funding from the European Community's Horizon 2020 (H2020) under the grant agreement No. 635405.

## 2 Introduction to deliverable 5.1: Report on composition of crambe and camelina oilseed side streams

Crambe (*Crambe abyssinica*) and camelina (*Camelina sativa*), both belonging to the flowering plant family *Brassicaceae*, are grown as an oil crop. Both crops are shown in Picture 1, and seeds thereof in Pictures 2a and 2b.

**Picture 1: Camelina (left) and crambe grown in Wageningen (NL) for field trials within EU-COSMOS.**




**Picture 2a (left): Fully matured camelina seeds just before harvesting showing the seedpods and the seeds after manualy opening the seed pods (picture of University of Nevada, Reno, USA).**

**Picture 2b (right): Camelina and crambe seeds at full maturity after opening the seed pods (picture out of D. Righini et al.: The bio-based economy can serve as the springboard for camelina and crambe to quit the limbo *OCL* 2016, 23(5) D504, DOI: 10.1051/ocl/2016021).**

Within COSMOS there is a clear focus to optimise the value generated not only from the oils, but also from the vegetative tissues like the straw and the residual oilseed material remaining after oil extraction. This seed residue is called *press cake* when obtained by an expeller press), or *meal* when obtained by solvent extraction). Press cake contains more residual oil than meal. Leaves will here either be considered as part of the straw or left out of consideration as they (partly) fall of during ripening and start decomposing. Last remaining part are the roots and stem after combine harvesting of the crop. Also these residues remain on the land and will be ploughed under.

Camelina meal and crambe meal (after processing) can be used as feed. In this project it will be fed to insects. Following digestion by insects, individual components like proteins, oils, fats etc. will be extracted by insect bio-refinery processes. Properties of these streams will be determined to estimate their value.

To balance the diet of the insects, to calculate the overall economics and to evaluate the social and environmental impact, the composition of the camelina and crambe straw, cake and meal needed to be analysed. For this a literature and internet survey was performed to make use of already available data. Additional analysis were performed in order to obtain data that was lacking. All these data are summarized in this deliverable report. This deliverable report is public and can be used freely as long as reference is made to this report.

## 3 Sample preparation before analysis

As press cake and meal were already fine and homogeneous materials they could be directly analyzed without further preparation. For the straw, milling was needed to get homogeneous material in order to obtain reliable analytical data.


**Picture 3: Crambe meal (top) and camelina meal (bottom).**

**Picture 4: Crambe, camelina and canola press cake produced by COSMOS partner UWM.**

### 3.1 Milling of crambe and camelina straw

Straw was precut with a Pallmann cutting mill (type PS 3-5, 5.5 kW, sieve 3 mm x 40 mm axial slides). Obtained material was further milled with a Retsch mill (type SM1, 1.5kW ) with a 500 µm sieve. In this way, homogenous material with a particle size below 500 µm of both types of straw was obtained.

## 4 Analytical data of camelina and crambe straw

In Table 1, composition data of camelina and crambe straw is displayed. As a reference, data for straw of more common crops are also displayed.

**Table 1: Analytical data of straw obtained from analyses within EU-COSMOS, based on data out of Feedipedia and out of literature**

| | | COSMOS Camelina Straw | COSMOS Crambe Straw | Barley straw | Oat straw | Wheat straw | Rye straw | Rape straw | Triticale straw | Camelina straw |
|---|---|---|---|---|---|---|---|---|---|---|
| **Dry matter** | % as is | 92.1 | 93.3 | 90.6 | 89.6 | 91 | 92 | 91.1 | 92.5 | 88.9-89.6 |
| **Crude protein** | % DM (N-c.f. 6.25) | 3.55 | 3.7 | 3.9 | 3.6 | 4.2 | 4.1 | 5.8 | 3.2 | |
| **Crude fibre** | % DM | 56.75 | 56.85 | 40.7 | 39.8 | 41.5 | 41.9 | 45.8 | 39.2 | |
| **NDF** | % DM | 80.6 | 79.8 | 80.1 | 76 | 77.5 | 77.9 | 77 | 75.1 | |
| **ADF** | % DM | 63.4 | 63.2 | 48.8 | 44.6 | 50 | 50.3 | 62.3 | 47.5 | |
| **Hemicellulose** | % DM | 17.2 | 16.6 | | | | | | | |
| **Lignin (ADL)** | % DM | 13.55 | 13.5 | 6.6 | 6.6 | 7.2 | 9 | 10.8 | | |
| **Cellulose** | % DM | 49.85 | 49.7 | | | | | | | |
| **Ether extract** | % DM | | | 1.4 | 1.5 | 1.4 | | 1.9 | 2.2 | |
| **Ether extract, HCl hydrolysis** | % DM | 0.5 | 0.3 | | 2.1 | | | 1.4 | | |
| **Ash** | % DM | 4.25 | 7.35 | 7.4 | 7.4 | 6.7 | 7.7 | 8.7 | 5.4 | 5.8-6.2 |
| **Starch (polarimetry)** | % DM | | | | | 1 | | | | |
| **Total sugars** | % DM | | | | | 1.2 | | | | |
| **Gross energy** | MJ/kg DM | | | 18.3 | 18 | 18.5 | 18.3 | 18.4 | 18.7 | |
| **Higher Heating Value** | MJ/kg | | | | | | | | | 15.1-15.5 |
| **Calcium** | g/kg DM | 7.85 | 10.8 | 4.6 | 2.5 | 4.8 | 4.1 | 9.8 | 2.7 | |
| **Phosphorus** | g/kg DM | 0.84 | 1.015 | 1 | 1.2 | 0.7 | 1.3 | 0.9 | 0.3 | |
| **Potassium** | g/kg DM | 10.9 | 19.65 | 14.4 | 14.7 | 11.2 | 12.2 | | 12 | |
| **Sodium** | g/kg DM | | | 0.9 | 2 | 0.1 | | | 0.1 | |
| **Magnesium** | g/kg DM | | | 1.2 | 1.1 | 1.2 | 1.4 | 2.6 | 0.7 | |
| **Manganese** | mg/kg DM | | | 28 | 33 | 32 | 18 | 30 | | |
| **Zinc** | mg/kg DM | | | 15 | 20 | 17 | 12 | 9 | | |
| **Copper** | mg/kg DM | | | 10 | 5 | 4 | 3 | 3 | | |
| **Iron** | mg/kg DM | | | 177 | 99 | 184 | 54 | 61 | | |

**Source:**
**EU-COSMOS analytical data**
**www.feedipedia.org**
**DOI: 10.1021/ef5026054**
**Energy Fuels 2015, 29, 1766–1775**

## 5 Analytical data of cake and meal obtained from analyses within EU-COSMOS, based on data from Feedipedia and literature

In Table 2, composition data of camelina and crambe cake (expeller extraction) and meal is displayed.

**Table 2: Analytical data of cake and meal obtained from analyses within EU-COSMOS, based on data from Feedipedia and literature.**

| | | Camelina (Camelina sativa) oil meal | COSMOS Camelina presscake / oil meal, expeller extraction | Camelina meal, Solvent extracted | COSMOS Camelina meal, solvent extraction | | Crambe (Crambe abyssinica) seeds | COSMOS Crambe presscake / oil meal, expeller extraction | Crambe (Crambe abyssinica) oil meal, expeller extraction | COSMOS Crambe meal, solvent extraction | Crambe (Crambe abyssinica) oil meal, solvent extraction |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Dry matter** | % as is | 90.5 | 87.9 | 92.5 | 91.7 | | 90.8 | 88.7 | 93 | 93.4 | 87.6 |
| **Crude protein** | % DM (N-c.f. 6,25) | 35.7 | 40.35 | 39 | 47.6 | | 21.3 | 27.9 | 33.3 | 51 | 45.3 |
| **Crude fibre** | % DM | 11.9 | 11.5 | | 12.2 | | 10.8 | 20.95 | 11 | 7.1 | 8.7 |
| **NDF** | % DM | 30.5 | 27.3 | 39.9 | 32.4 | | 61 | 30.6 | 26.1 | 16.3 | 29.8 |
| **ADF** | % DM | 17.9 | 14.1 | 25.4 | 15.1 | | 51.7 | 24.55 | 21.2 | 10.1 | 22.3 |
| **Hemicellulose** | % DM | | 13.2 | | 17.35 | | | 6.05 | | 6.2 | |
| **Lignin (ADL)** | % DM | 6.4 | 3.6 | | 3.95 | | | 10.2 | | 2.05 | |
| **Cellulose** | % DM | | 10.5 | | 11.1 | | | 14.35 | | 8.05 | |
| **Ether extract** | % DM | 15.6 | | | | | 55 | | 20.8 | | 2.8 |
| **Ether extract, HCl hydrolysis** | % DM | | 15.7 | 3 | 1.55 | | | 12.9 | | 1.45 | |
| **Ash** | % DM | 6.9 | 5.3 | | 6.3 | | 3.4 | 7.2 | 7.3 | 7.75 | 7.4 |
| **Starch (polarimetry)** | % DM | | | | | | | | | | |
| **Total sugars** | % DM | 4.4 | | | | | | | | | |
| **Gross energy** | MJ/kg DM | 22.1 | | | | | 30.5 | | 23 | | 19.7 |
| **Higher Heating Value** | MJ/kg | | | | | | | | | | |
| **Calcium** | g/kg DM | 3.6 | 3.95 | | 4.755 | | | 12.55 | | 8.53 | 9 |
| **Phosphorus** | g/kg DM | 8.7 | 9.68 | | 11.8 | | | 8.3 | | 15.95 | 10.6 |
| **Potassium** | g/kg DM | 13.2 | 12 | | 14.65 | | | 13.35 | | 12.4 | 11.1 |
| **Sodium** | g/kg DM | 0.1 | | | | | | | | | 0.2 |
| **Magnesium** | g/kg DM | 4 | | | | | | | | | 4.5 |
| **Manganese** | mg/kg DM | 24 | | | | | | | | | 31 |
| **Zinc** | mg/kg DM | 48 | | | | | | | | | 48 |
| **Copper** | mg/kg DM | 7 | | | | | | | | | 6 |
| **Iron** | mg/kg DM | 137 | | | | | | | | | 192 |

**Source:**

**EU-COSMOS analytical data**

**www.feedipedia.org**

**C.L. Ye et al. / Aquaculture 450 (2016) 397–404**